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EFFLUENT AND WATER QUALITY SAMPLING SURVEY - ABITIBI-PRICE AND WINNIPEG RIVER - AUGUST 1986

by

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Effluent and Water Quality Sampling Survey

Abitibi-Price Ltd. and Winnipeg River

In the Vicinity of Pine Falls, Manitoba

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ABSTRACT

A sampling program was carried out at Abitibi-Price Ltd. and on the Winnipeg River in the vicinity of Pine Falls, Manitoba, to assess effluent quality from the pulp and paper mill and the impact of the effluent on the chemical quality of the river. Effluent quality was compared to the allowable discharges under the federal Pulp and Paper Effluent Regulations, and river water quality was compared to the proposed Manitoba Surface Water Quality Objectives and the Canadian Drinking Water Quality Guidelines. No measurable impact on the receiving stream water quality was measured beyond the immediate mixing zone, because of the high dilution factor in the river. Drinking water quality at the Fort Alexander Indian Reserve, located downstream of the mill outfall, was not considered to be adversely affected by the mill effluent.

RESUME

Des échantillons d'eau ont été prélevés à la fabrique Abitibi-Price Ltée et dans la rivière Winnipeg aux environs de Pine Falls, au Manitoba, pour nous permettre d'évaluer la qualité des effluents de la fabrique de pâtes et papiers ainsi que leurs répercussions sur l'équilibre chimique de la rivière. On a étudié la qualité des effluents en la comparant au taux de rejets permis en vertu du Règlement fédéral sur les effluents des fabriques de pâtes et papiers. Par ailleurs, on a comparé les resultats obtenus quant à la qualité de l'eau de la rivière aux Objectifs concernant la qualité des eaux de surface du Manitoba et aux Lignes directrices sur la qualité de l'eau potable au Canada. Comme la rivière a un haut taux de dilution, on n'a constaté, dans la zone de mélange, aucune répercussion mesurable des effluents sur la qualité de l'eau du cours récepteur. Il est ressorti de l'étude que les effluents de la fabrique ne nuisent pas à la qualité de l'eau potable de la réserve indienne de Fort Alexander, située en aval de l'exutoire de la fabrique.

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Effluent and Water Quality Sampling Survey
Abitibi-Price Ltd. and Winnipeg River
In the Vicinity of Pine Falls, Manitoba

1.0 Introduction

A sampling program was carried out by Environmental Protection (EP) of Environment Canada during August 25-28, 1986, at the Abitibi-Price Ltd. paper mill in Pine Falls, and on the Winnipeg River in the vicinity of the mill outfall.

A sampling program to assess the quality of effluent from Abitibi had been originally planned by Environmental Protection. However, concerns had been expressed by the Fort Alexander Indian Band about deterioration of the drinking water quality of the Winnipeg River downstream of Abitibi. Therefore, an expanded sampling program was designed, with input from Health and Welfare Canada, to address some of those concerns.

Environmental Protection's most recent assessment of Winnipeg River water quality was conducted in 1972 (EPS, 1972). The study, done in conjunction with Fisheries and Oceans Canada, found that the Winnipeg River was not chemically polluted to any significant degree. Aquatic organisms were adversely affected, however, up to four miles downstream of the outfall. This was

indicative of a pollution problem associated with the mill effluent.

Several changes resulting in improved effluent quality have occurred at Abitibi since the 1972 survey. The 1986 sampling program was conducted to determine the impact of the effluent on the chemical quality of the river downstream of the outfall, to assess the effluent quality with respect to the allowances specified in the federal Pulp and Paper Effluent Regulations, and to serve as a basis for continuing discussions with Abitibi-Price on effluent quality improvements.

2.0 Background

The Abitibi-Price Ltd. pulp and paper mill in Pine Falls currently produces about 520 air-dry tonnes of newsprint per day. The mill has been in operation since 1927, and discharges approximately 43,000 cubic metres (9.5 million Imperial gallons) of wastewater per day into the Winnipeg River via a single, 120 cm-diameter discharge line.

The mill uses a combination of the sulphite and groundwood processes to produce newsprint. About 65-70 percent of the pulp is produced mechanically in the groundwood mill, while 25-30 percent is produced chemically in the sulphite process. Up to 5 percent purchased kraft pulp may also be used, depending on the required finished product. The sulphite cooking liquor is produced from the combustion of sulphur in air to form SO_2, followed by absorption of the SO_2 in a sodium-based solution to form an acidic solution of sodium bisulphite and free SO_2 in water.

Current pulping yields are 62-66 percent for the sulphite mill (medium yield) and 97.2 percent for the groundwood mill. If necessary, the groundwood pulp is brightened with sodium hydrasulphite prior to use.

The Pine Falls mill is classed as an existing mill and is

not currently regulated under the provisions of the federal Pulp and Paper Effluent Regulations. When the regulations were promulgated in 1971, the intent was to negotiate compliance schedules with individual mills, whereby improvements in effluent quality would be achieved over a negotiated time frame. This approach was taken with many mills, but wastewater treatment technology proved to be uneconomic for small sulphite mills. Improvements in effluent quality at mills such as Abitibi-Price in Pine Falls have, instead, focussed on internal, in-plant improvements, while research and development continued on alternative, more environmentally acceptable pulping processes such as thermomechanical pulping (TMP) and chemi-thermomechanical pulping (CTMP). These alternative processes have now been adopted at several mills, and are under consideration for the Pine Falls mill.

The federal Pulp and Paper Effluent Regulations have been under review since 1982, and revised requirements for the industry are expected to be released in the near future.

3.0 Sampling Methods

Samples were collected during August 25-28, 1986, from the main mill sewer, the Winnipeg River and water treatment plants on the Fort Alexander Indian Reserve (Figure 1). During the sampling period, the mill was in normal operating status, producing an average of 534 air-dry tonnes of newsprint per day.

Three separate 24-hour composite samples of the mill's wastewater were collected at 15-minute intervals during the period of August 25-27. Samples were collected from a manhole on the outfall line using an Isco Model 1680 composite sampler.

River water samples were collected on August 25, 26 and 27 from five locations on the Winnipeg River, upstream and downstream of the mill's outfall. Four transects located approximately 0.2 km, 1.5 km, 3.5 km and 6.0 km downstream of the outfall (Figure 1) were sampled at points located one-quarter, one-half and three-quarters of the way across the river, in order to obtain a representative sample across each transect. Since mixing paterns in the river were not known, a Van Dorn sampler was used to collect grab samples at a 3-metre depth, which represented a mid-depth point for most locations. These grab samples were then combined to form one daily composite sample per transect. At the upstream site, located just below the Manitoba Hydro Powerview dam, only one station near shore was sampled.

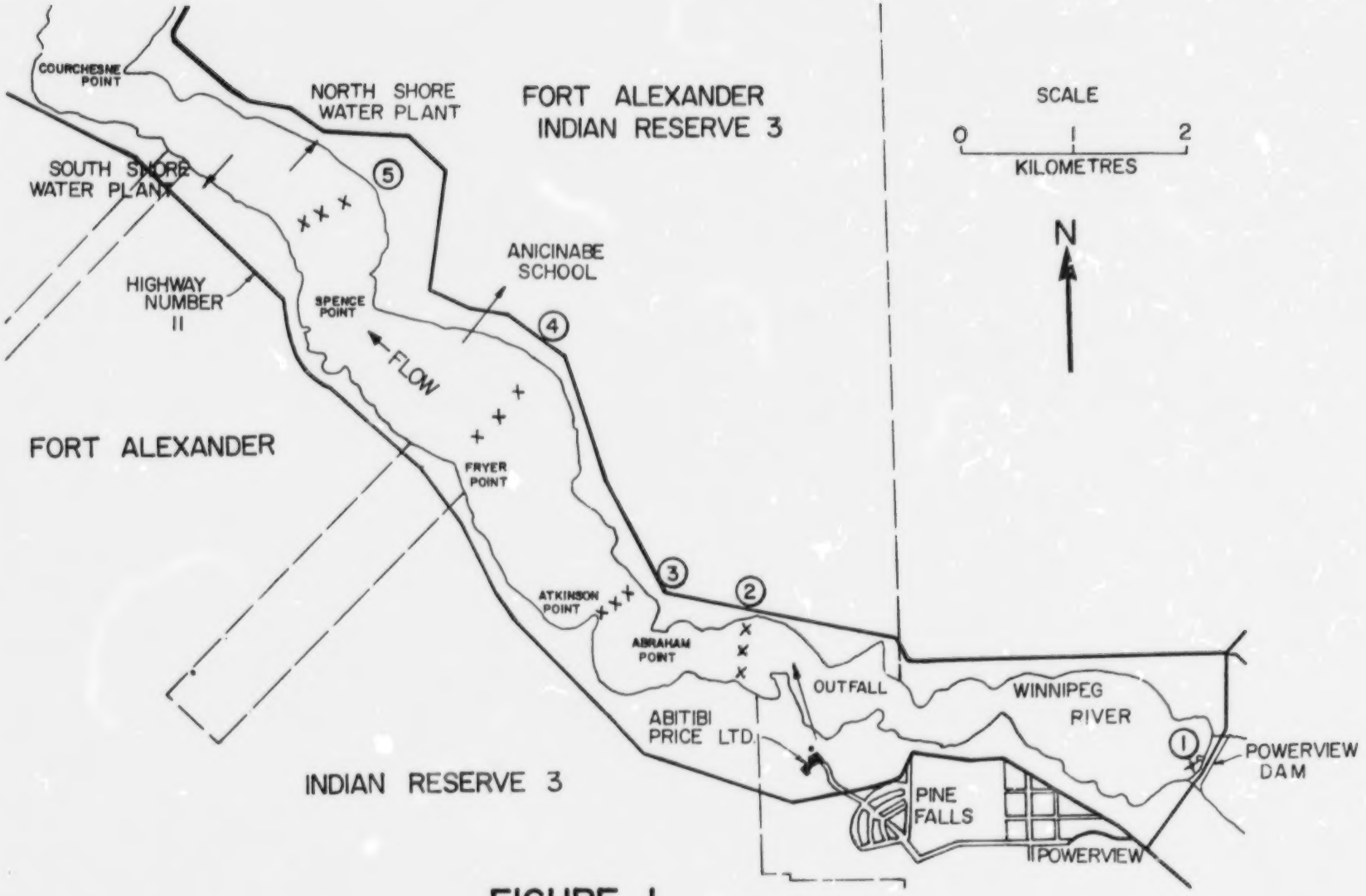

FIGURE 1
SAMPLING LOCATIONS - WINNIPEG RIVER
1986

Grab samples of treated drinking water were collected on August 26 and 28 from three locations on the Fort Alexander Reserve: the two water treatment plants serving the north and south shore communities, and the treatment plant at the Anicinabe School on the north shore.

Where required, samples were preserved immediately in the field using preservation techniques described in the Environment Canada Environmental Laboratory Manual (1979), then stored on ice at 4°C during transit to labs in Winnipeg, Edmonton and Halifax.

Tannin and lignin analysis was carried out at the W.M. Ward Technical Services Laboratory in Winnipeg using a Hach Kit (Model TA-3). This is the procedure currently in use. Trihalomethane analyses were done at the same lab using Method 514, Standard Methods, 15th Edition (APHA, 1980).

Resin acid analysis was done by the Environmental Protection lab in Halifax, using a slightly modified method to that described in the Environmental Laboratory Manual (1979). The modifications are outlined in Appendix A.

All other chemical analyses were carried out at the Environmental Protection lab in Edmonton using methods described in the Environmental Laboratory Manual (1979).

Bacteriological examinations for total and fecal coliforms were done at the Cadham Provincial Laboratory in Winnipeg using the Most Probable Number (MPN) method.

Bioassay testing, involving three test methods, was carried out at the Environmental Protection laboratory in Edmonton. Trout bioassays were not conducted because of the laboratory's limited testing capabilities at the time of the survey. The test procedures used are outlined in Appendix B.

4.0 Results and Discussion

4.1 Winnipeg River Water Quality

Analytical results for all samples collected are summarized in Table 1. These represent average values, calculated from the individual sample results (Appendix C).

Parameters for analysis were selected on the basis of the following criteria:

1) expected presence and concentration in the effluent, based on previous sampling results from Abitibi and similar mills,

2) laboratory capability and availability,

3) expected concentration in the river, based on the dilution ratio,

4) environmental and health concerns identified for particular compounds that might be present in the effluent.

The most recent flow data available for the Winnipeg River (Water Survey, 1986) show that, in 1985, average flows were 1390

TABLE 1

AVERAGE EFFLUENT AND RECEIVING WATER QUALITY DATA[1]

ABITIBI-PRICE AND WINNIPEG RIVER

1986

(mg/L unless noted)

	STN. 1	MILL EFFLUENT	STN. 2	STN. 3	STN. 4	STN. 5	ANICINABE SCHOOL	NORTH SHORE WATER PLANT	SOUTH SHORE WATER PLANT
BOD_5 - Total	--[2]	633	--	--	--	--	--	--	--
- Dissolved	--	543	--	--	--	--	--	--	--
Residue - Total	89	2168	98	92	93	86	91	118	115
- Total Volatile	--	1266	--	--	--	--	--	--	--
- Non-Filt.	12	173	14	13	13	16	3	11	8
- Vol. Non-Filt.	--	155	--	--	--	--	--	--	--
- Filterable	83	--	86	85	80	82	89	95	102
Chemical Oxygen Demand	--	2330	--	--	--	--	--	--	--
pH (units)	8.0 - 8.1	4.3 - 6.8	8.0	8.0	8.0	7.9	--	7.1	7.7
Conductivity (umho/cm)	94	671	94	94	93	96	--	160	130
Sulphate	8	319	8	8	8	8	8	41	12
Total Carbon	20	775	22	20	20	21	20	13	21
Inorganic Carbon	10	4	10	10	10	10	10	9	10
Organic Carbon	10	771	12	10	10	11	10	4	11
Colour (TCU)	53	408	53	52	55	48	35	5	40

TABLE 1 (CONT'D)

	STN. 1	MILL EFFLUENT	STN. 2	STN. 3	STN. 4	STN. 5	ANICINABE SCHOOL	NORTH SHORE WATER PLANT	SOUTH SHORE WATER PLANT
Sodium	2.78	151	4.90	2.79	2.73	2.86	5.91	11.0	7.13
Mercury	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Copper	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.46	<0.02
Nickel	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Zinc	0.029	0.101	0.039	0.025	0.019	0.024	0.019	0.828	0.015
Lead	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Aluminum	0.53	3.53	0.60	0.63	0.59	0.68	0.24	0.35	1.71
Cadmium	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Phenols	0.05	1.45	0.07	0.03	0.01	0.04	0.05	0.02	0.06
Resin Acids	—	3.0	<0.05	<0.05	<0.05	<0.05	--	--	—
Tannin & Lignin	2.5	58.8	3.5	3.0	3.0	3.2	—	--	—
Trihalomethanes[3] (ug/L)									
- $CHCl_3$	—	—	--	--	--	—	<1.1	192	87.8
- $BrCHCl_2$	—	—	--	--	--	--	<1.0	2.0	3.2
- $CHBr_2Cl$	—	—	--	--	--	--	<1.0	<1.0	<1.0
- $CHBr_3$	--	--	--	--	--	--	<1.2	<1.2	<1.2
Coliforms (MPN/100mL)									
- Total	12	>150,000	39 - >1500	280	460	1100	—	--	--
- Fecal	—	57,300	43	0	--	--	--	--	—

Notes: (1) See Appendix C for individual values.
(2) — Analysis not done.
(3) Individual values not shown in Apperdix C since only one analysis per location was done.

cubic metres per second, while minimum flows were 668 cubic metres per second. This provides an average dilution ratio of 2800:1 for the effluent, and a minimum dilution ratio of greater than 1000:1, assuming wastewater flow from the mill averages 43,000 cubic metres per day (0.5 cubic metres per second).

At such high dilution factors, the concentrations of most compounds in the effluent were expected to be reduced to very low levels in the river. This was found to be the case. On the basis of the physical and chemical parameters examined (Table 1), there was no measurable change in downstream receiving water quality beyond the immediate discharge zone (near Station 2). Station 2, located about 200 metres downstream of the outfall, had only slightly higher average values of total residue, sodium, zinc, tannin and lignin, and phenols than those at Station 1, upstream of the mill effluent discharge point . Some of the variations noted between samples at Station 2 (Appendix C) were attributed to sampling variability, and uneven mixing of the effluent near the outfall. No noticeable changes in water quality, attributable to the effluent from Abitibi, were detected beyond Station 2. Average concentrations of all parameters were similar to those found in the upstream samples.

Results obtained in this survey were compared with the Draft Manitoba Surface Water Quality Objectives (Williams, 1986) for Class 2 waters (cold water aquatic life and wildlife) (Table 2).

TABLE 2

DRAFT MANITOBA SURFACE WATER QUALITY OBJECTIVES*

Parameter	Class 1 Domestic Consumption	Class 2 Fish/Wildlife
Cadmium (Acid Sol.)	0.005 mg/L	0.0011 mg/L **
Colour (TCU)	15 units	--
Copper (Acid Sol.)	1.0 mg/L	0.012 mg/L**
Filterable Residue	500 mg/L	--
Lead (Acid Sol.)	0.05 mg/L	0.0032 mg/L**
Mercury (Total)	0.001 mg/L	0.006 ug/L
Nickel (Acid Sol.)	--	0.096 mg/L**
Non-Filterable Residue	--	25 mg/L
pH	6.5 - 8.5	6.5 - 9.0
Phenols	0.002 mg/L	0.001 mg/L
Sodium	400 mg/L	--
Sulphates	500 mg/L	--
Trihalomethanes, total	350 ug/L	--
Zinc (Acid Sol.)	5.0 mg/L	0.047 mg/L

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* As proposed by Manitoba Environment and Workplace Safety and Health, 1986.

** Assuming a hardness value of 100 mg/L as $CaCO_3$. Lower hardness levels mean lower objective values. Typical hardness of Winnipeg River is about 60 mg/L.

The Class 2 objectives are generally the most stringent of the various classes proposed. Objectives have been proposed for most, but not all, of the parameters tested for.

All physical and chemical parameters analyzed for, except phenols, met the draft Manitoba Surface Water Quality Objectives. Phenol levels were found to be consistently above the objective level of 0.001 mg/L for Class 2 waters. Phenol concentrations, however, were high at both upstream and downstream sampling locations. In contrast, phenol concentrations, as monitored routinely by Inland Waters and Lands of Environment Canada at Pointe du Bois, about 100 km upstream of Pine Falls, normally range from less than 0.001 mg/L to 0.009 mg/L (Water Quality, 1983) (Chacko, pers.comm.). The high concentrations found in this survey suggest that there may be a source of phenol contamination between Pointe du Bois and Pine Falls.

Effluent from the Abitibi mill contained phenol concentrations of 1.6-1.9 mg/L, resulting in a slight increase in concentration at Station 2, but concentrations decreased to background levels at Station 3 (Table 1).

Direct comparison of all of the heavy metal concentrations in the Winnipeg River with the Manitoba water quality objectives could not be made because: a) the analytical technique used had too high a detection limit for some metals, and b) Manitoba's

objectives for most metals call for acid soluble while total metals were determined in this study. The total value, however, includes both acid soluble and suspended forms. No significant concentrations of these metals were identified in the effluent samples, and therefore, no increase in concentration above background levels would be expected.

Toxicity tests were carried out as a means of identifying biological effects of compounds in the effluent. These tests act as screening tools, and provide inexpensive, yet sensitive, means of identifying environmental concerns other than through chemical testing. Reasons for particular results may not always be clear without extensive chemical analysis, but these tests do provide evidence of synergistic and other effects that may not be evident from chemical analysis alone.

Two samples of river water collected at Station 2 were acutely toxic to bacteria in the Microtox bioassay test (Table 3). Phenols from the mill may have been a contributing factor, although acute toxicity to aquatic organisms normally occurs at much higher concentrations (greater than 2 mg/L) than those found in these samples (US EPA, 1980). Phenol concentrations in the August 26 and 27 samples from Station 2 were 0.08 and 0.09 mg/L respectively (Appendix A), higher than those at other downstream locations. However, the toxicity observed at Station 2 was inconsistent with the August 27 sample from Sation 1, which

TABLE 3

TOXICITY TESTS RESULTS SUMMARY
ABITIBI-PRICE AND WINNIPEG RIVER, 1986

Sampling Station	Date Sampled	Microtox Bioassay	Algal Bioassay	Daphnia magna Bioassay
1	25 Aug. 86	NT(1)	NT	NT
1	26 Aug. 86	NT	NT	NT
1	27 Aug. 86	NT	NT	NT
2	25 Aug. 86	NT	NT	NT
2	26 Aug. 86	83.2(2)	NT	NT
2	27 Aug. 86	53.2	NT	NT
3	25 Aug. 86	NT	NT	NT
3	26 Aug. 86	NT	NT	NT
3	27 Aug. 86	NT	NT	NT
4	26 Aug. 86	NT	NT	NT
4	27 Aug. 86	NT	NT	NT
5	26 Aug. 86	NT	NT	NT
5	27 Aug. 86	NT	NT	NT
Effluent	26 Aug. 86	2.4(2)	2.7(2)	21.6(2)
Effluent	27 Aug. 86	2.6	2.8	7.3
Effluent	28 Aug. 86	3.4	2.1	4.5

Notes:

1 - NT = non-toxic

2 - EC_{50} values (%). These values show the concentration of sample toxic to 50% or more of the test organisms. As an example, an EC_{50} of 83.2% means that a mixture of 83.2% sample + 16.8% clean water was toxic. An EC_{50} value of 2.4% means that a mixture of 2.4% sample + 97.6% clean water was toxic. The smaller the EC_{50} value, the more toxic the sample is.

is upstream of the mill, and had the highest phenol concentration (0.10 mg/L), but was non-toxic. Thus, while phenols may have been a contributing factor, they were not likely the sole factor in causing the toxicity at Station 2.

Phenol toxicity varies widely, and depends on water quality characteristics such as dissolved oxygen concentrations, salinity, temperature and other parameters (US EPA, 1980) (Bergman et al., 1979). Changes in water quality close to the mill outfall could increase phenol toxicity, but the high dilution ratio in the river would result in conditions returning to near background within a short distance. Also, certain forms of phenols, such as chlorophenols, are more toxic than others (Bergman et al., 1979) but the analytical technique used for this study did not differentiate between these forms. While significant levels of chlorophenols were not expected to be present in Abitibi's effluent (because they do not utilize a chlorine bleaching process), small amounts of chlorophenols could be formed through reaction of phenols with chlorine from other sources, such as chlorination of the mill's domestic water supply.

Resin acids, another toxic constituent of pulp mill effluent (see Section 4.2), may have also been responsible for the toxicity in the Microtox assay. Limited laboratory availability, however, did not allow resin acid analysis on all samples

collected, so the actual concentrations in Station 2 samples from August 26 and 27 cannot be accurately stated. Acute toxic effects on fish would not be expected at concentrations of less than about 0.2 mg/L (Leach and Thakore, 1976), but differing sensitivities between bioassay testing methods, and under different water quality conditions have been reported in the literature (Envir. Canada, 1986), and could account for the toxicity observed at Station 2. Also, synergism between resin acids, phenols or other mill constituents cannot be ruled out.

A limited amount of data was collected on microbiological quality of the Winnipeg River and Abitibi's effluent (Table 1). The data were not considered sufficient to characterize the bacterial quality of the river, but they do suggest that Abitibi may be contributing to the bacterial contamination of the Winnipeg River. Further sampling would be required to confirm this.

4.2 Abitibi Effluent Quality

The last comprehensive effluent sampling survey carried out at Abitibi by Environmental Protection was in 1981 (Table 4). Since that time, suspended solids (i.e. non-filterable residue) levels from the mill have decreased from 255 mg/L to 173 mg/L, based on present survey results. This reduction is consistent with company-reported effluent quality data from recent months.

TABLE 4

Effluent and Raw Water Quality Data[1]

Abitibi-Price - June 1981

(mg/L unless noted)

PARAMETER	CONCENTRATION	
	Raw Process Water (from Winnipeg River)	Effluent (24-hr. Comp.)
BOD_5 - Total	<2	532
Residue - Total	110	1850
- Non-Filt.	11	255
- Vol. Non-Filt.	2	235
Chemical Oxygen Demand	41	2125
pH (units)	7.4	5.6 - 6.7
Conductivity (umho/cm)	130	565
Total Carbon	25	756
Inorganic Carbon	11	6
Organic Carbon	14	750
Colour (TCU)	80	550
Mercury	<0.0002	<0.0002
Phenols	--	0.99
Total Alkalinity	46	43

Notes: 1 - Data based on 24-hr. composite samples of effluent collected by Environmental Protection on June 23-25, 1981 and a single grab sample of raw process water collected June 24.

Suspended solids losses have been reduced through in-plant modifications adopted over the last several years. The changes have involved, among others, improvements in the operation of the woodroom clarifier, which provides primary treatment for the wet-drum debarker effluent, and minimization of discharge of high-strength wastewaters to the sewers. Various filter screens have also been installed to remove solids, and a rich whitewater filter was recently installed.

Effluent colour has also shown an improvement, from 550 true colour units in 1981, to 408 true colour units in 1986. Results for all other parameters were similar in both surveys.

The effluent collected in this study was acutely toxic in all three bioassay tests performed. This is consistent with previous Environmental Protection bioassay tests using rainbow trout. Both the Microtox and algal bioassay results (Table 3) showed that a mixture of about 3 percent effluent/97 percent water was toxic to 50 percent or more of the organisms. The daphnia bioassays showed a slightly lower toxicity. The effluent from the mill can therefore be considered to be acutely lethal.

Several toxic compounds have been identified in sulphite and groundwood mill effluents, including resin acids, fatty acids, wood alcohols, wood fibres and phenolic compounds (Walden, 1976) (Leach & Thakore, 1977). Resin acids are normally responsible

for most of the toxicity, particularly from softwood pulping species such as jack pine, spruce and fir (Leach & Thakore, 1977). Abitibi uses a 80-85 percent spruce and balsam fir mix, and 15-20 percent jack pine as raw furnish to the mill.

Concentrations of resin acids found in this survey were 3.0 mg/L. Resin acids have been shown to be toxic to fish at levels as low as 0.2 mg/L, and are formed in both the debarking and pulping processes (Leach & Thakore, 1977). The debarking operation and the groundwood and sulphite pulping processes used at Abitibi all contribute to the toxicity of the effluent. The sulphite cooking liquor is not recovered or treated prior to discharge to the river, as no economical means of treatment has been developed for small sulphite mills such as Abitibi. The groundwood and debarking processes result in the discharge of toxic compounds, such as wood alcohols, that dissolve in the water during the mechanical action in these processes (Leach & Thakore, 1977).

The federal Pulp and Paper Effluent Regulations, promulgated in 1971 under the Fisheries Act, provide for maximum allowable discharges of 5-day biochemical oxygen demand (BOD_5) and total suspended solids (TSS) from new, expanded and altered mills. The effluent must also be non-toxic to fish in a 96-hour bioassay test using rainbow trout. While Abitibi is considered to be an existing mill and is not currently under federal regulation, a

comparison was made between actual discharges from Abitibi since 1976 and during this survey, and the allowable discharges from a new mill utilizing the same processes (Table 5). Average TSS discharges during this survey were slightly lower than those allowed from a new mill under regulation, while BOD_5 discharges were about 50 percent higher. The effluent was acutely toxic, although the bioassay testing procedures followed may not produce results that are directly comparable to fish bioassays as required under the regulations.

Comparison of longer term averages (since 1976) shows that Abitibi has made significant progress in reducing suspended solids losses, despite temporary problems encountered in 1984, when a paper-making change was adopted in the mill (Table 5). Discharges of BOD_5, however, have not been reduced to the same extent, as no chemical recovery is practised. The reductions in average BOD_5 discharges have likely been achieved as a result of the reduced suspended solids losses.

Further significant reductions in BOD_5 and toxicity levels in Abitibi's effluent would require an extensive mill modernization program. Recently developed pulping processes such as thermomechanical pulping (TMP) and chemi-thermomechanical pulping (CTMP) have gained wider acceptance and use over the last ten years as alternatives to the sulphite process. Thermomechanical pulping involves the production of wood pulp by

TABLE 5
Comparison of Abitibi Effluent Quality
With Allowances Under Federal Regulations
(1976-1986)

Year	Ave. Daily[1] Production (AD tonnes)	Ave. Daily[1] Flow ($m^3 \times 10^3$)	Ave. Daily TSS Discharges (kg/ADt)	Ave. Daily BOD_5 Discharges (kg/ADt)	Acute Toxicity
1976	445	45.5	29.7	108.8	Toxic[2]
1977	457	45.0	22.9	112.9	"
1978	471	45.2	14.6	89.4	"
1979	474	46.9	13.1	77.1	"
1980	489	46.7	16.5	50.4	"
1981	468	44.7	17.1	44.7	"
1982	469	41.4	14.1	53.7	"
1983	482	42.4	15.3	54.1	"
1984	469	46.6	20.5	63.4	"
1985	507	41.7	16.3	78.8	"
1986[3]	518	43.2	14.5	79.2	"
Aug. 25-28 1986	532	42.9	14.0[4]	51.1[4]	"
Allowances Under Federal Pulp and Paper Effluent Regulations			14.6	34.3	Non-Toxic

Notes:
1. Company-Reported Data
2. Effluent was assumed to be toxic, although toxicity tests were not necessarily done each year. No significant process changes have been adopted that would alter toxicity.
3. Up to October 31
4. Calculated using Environmental Protection survey results

steam softening of the chips under pressure, followed by pressurized mechanical refining. Chemi-thermomechanical pulping is similar, but sodium sulphite is used along with steam to soften the wood chips prior to refining. Both of these processes have significantly higher yields than medium-yield sulphite (90% or more versus 65%), but both produce a toxic effluent, with a high BOD_5 concentration. Suspended solids levels are normally similar or slightly lower than those from the sulphite process.

The main advantages of TMP and CTMP over the sulphite process, other than differences in pulp and paper quality, are the smaller mass loadings of pollutants to the environment (the volume of effluent is much lower, but the concentrations of pollutants is higher), and the amenability of the effluents to treatment on an economically viable basis. Research is currently underway that indicates anaerobic pretreatment of wastewater, followed by aerobic polishing, should be able to produce a non-toxic effluent that is low in BOD_5 concentration (Hall, pers. comm.).

4.3 Drinking Water Quality - Fort Alexander Indian Reserve

Drinking water treatment at the two Fort Alexander community plants consists of coagulation and flocculation (using alum), followed by sedimentation and chlorination. The Anicinabe School has a sand and activated carbon filtration system, followed by

chlorination.

The analytical results for the treated drinking water samples collected from the Fort Alexander Reserve are shown in Table 1. Phenol and colour values were above the maximum acceptable concentration limits in the Guidelines for Canadian Drinking Water Quality (1978) (Health and Welfare Canada, 1978) and the draft Manitoba Surface Water Quality Objectives (Table 2). The values were comparable, however, to those from the sampling location upstream of the mill. Phenols, particularly chlorophenols, are undesirable because of the taste and odour problems they create in drinking water. The US EPA (1980) has proposed a phenol criterion of 0.3 mg/L for drinking water, on the basis of taste and odour considerations. This is well below levels that the EPA considers to present health hazards.

Trihalomethane (THM) values were below Health and Welfare Canada's maximum acceptable concentration of 350 ug/L, but were considerably higher than the objective limit of 0.5 ug/L. Values of less than 350 ug/L are not considered to pose a health hazard (Health and Welfare Canada, 1978).

All other parameters were within the guideline and objective values. The slight increases in copper and zinc levels in the north shore treatment plant sample from August 28 were attributed to insufficient flushing of the lines before sample collection.

Other values above background levels were attributed to the addition of water treatment chemicals in the water treatment process. There did not appear to be any adverse impact on drinking water quality attributable to the mill discharge.

5.0 Conclusions

On the basis of the physical and chemical data collected, there was little or no measurable impact from the mill effluent on the receiving stream quality downstream of the outfall, primarily because of the high dilution factor in the Winnipeg River. Some parameters showed increased levels in the area immediately downstream of the outfall, but concentrations of pollutants returned to background levels within 1.5 km of the outfall.

No conclusions, however, can be reached on the impact of the effluent on the biological community in the river, as this aspect was not investigated. Bioassay testing suggests that the effluent could be toxic to certain aquatic organisms in the immediate discharge area, depending on the dilution ratio and the mixing patterns in the outfall area.

Suspended solids losses from the mill were lower than in 1981 and effluent colour had improved, but there did not appear to be any other significant changes in effluent quality since that time. Decreases in suspended solids occurred as a result of in-plant improvements and modifications adopted over the last several years.

A comparison of mill effluent quality with the BOD_5,

suspended solids and toxicity provisions of the federal Pulp and Paper Effluent Regulations showed that the suspended solids discharges were lower than the allowable levels, while BOD_5 levels were being exceeded. The mill effluent was also acutely toxic, but a direct comparison between the toxicity tests used and fish bioassays using rainbow trout could not be made without further data. Recent developments in pulping processes and wastewater treatment technologies have demonstrated that reductions in pollutant loadings to the environment can be achieved with adoption of these technologies. However, significant reduction in effluent toxicity would also require incorporation of external wastewater treatment facilities such as anaerobic and aerobic treatment plants.

Preliminary data collected indicated that Abitibi may be contributing to bacterial contamination of the Winnipeg River downstream of the outfall, but additional data should be gathered to address this matter.

No adverse impact on drinking water quality at Fort Alexander Indian Reserve was detected that was attributable to the mill effluent. Phenol and colour values were high in both the river water and treated water, but the source of phenol contamination would appear to be upstream of Pine Falls.

6.0 References

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7.0 Acknowledgements

The assistance of the EP laboratory in Halifax in providing analytical services is gratefully acknowledged.

APPENDIX A

Modifications to Resin Acid Analytical Procedure Contained in 1979 Environmental Laboratory Manual

1. Prior to the extraction of resin acids at pH 2.0, step 1 of the procedure, samples are made to pH 10 with 50% sodium hydroxide and extracted with two 50 mL portions of hexane in order to remove basic and neutral interferences.

2. Resin acids are extracted from 500 mL water samples with 100 ml and then two 50 mL volumes of benzene in lieu of the four 100 ml portions of diethyl ether as described in step 2.

3. Sample extracts are injected onto the GC column in benzene rather than in methanol as described in steps 7 and 8.

4. Since all resin acids of interest elute from the GC column subsequent to nonadecanoate, only areas of peaks with retention times greater than that of a nonadecanoate standard are summed and used in the final calculations.

Analysis of replicate water samples fortified with dehydroabietic acid (2.2 ppm) using the modified procedure yielded a mean recovery greater than 90% (CV=6.6%).

APPENDIX B

TOXICITY TESTING PROCEDURES

Three standard toxicity tests were performed in this study: Daphnia magna, acute effect (immobilization); Selenastrum capricornutum, acute effect (growth inhibition); the Microtox system, acute effect (metabolic inhibition).

Daphnid

Invertebrate toxicity testing was performed utilizing the cladoceran Daphnia magna. The method selected was a modification of the standard method for daphnia acute toxicity testing currently in use at the EP Aquatic Toxicology Laboratory (Neufeld, 1983). In general, the procedure involves production of F1 generation daphnids (less than or equal to 24 hours old) from random age adults. These F1 generation daphnids are reared and become the brood adults for the F2 generation (24-48 hours old) that are used for testing. This two generation culture process results in the production of organisms with a consistent, sensitive toxic response (Leonhard, 1979).

Culture and diluent water for testing were not altered or manipulated for specific water quality parameters. In all cases, stock and brood cultures underwent a minimum 4 week acclimation period for changes in water quality and/or temperature before being used for testing.

Culturing and testing were carried out in an environment room with controlled temperature (10°C) and photoperiod (16 hours light:8 hours dark).

Daphnia were fed a food mixture as described in ASTM (1977) at a rate of approximately 0.01 mg/mL solids per day. Feeding occurred during the tests at 0 hours and 48 hours at 0.66 mL solids per 100 mL sample.

The tests performed were 96 hour acute effect assays with immobilization as the observed effect. Immobilization was recorded at 24 hour intervals by observation of absence of movement of the antennae. Tests were performed in glass vessels using a loading rate of 10 daphnids per 100 mL sample. To minimize the loss of volatiles, the containers were sealed for the duration of the tests. Test concentrations were replicated once and results were pooled for each concentration.

Algae

Algal assay testing was performed utilizing a modified version of the EPA Algal Assay Bottle Test with the algae Selenastrum capricornutum. Toxic effects were expressed as percent inhibition of biomass production.

The standard algal assay was modified according to the

methods proposed by Blaise et al, (1982) which substitutes disposable multiple well microplates for the standard flasks. Additionally, initial cell concentrations were increased to 100,000 cells/mL which resulted in the test period being reduced from 8 to 4 days (period to reach maximum standing crop).

Cell counts were performed on a Coulter counter (Model ZB) equipped with a 100 micron aperture tube. Results were corrected for coincidence and converted to percentages of the maximum standing crop.

Microtox

The Microtox test is a proprietary method developed by Beckman Instruments, Carlsbad, California, utilizing a lyophilized bioluminescent bacteria as a test reagent. Rehydrated, the bacteria emit a measurable quantity of light. The presence of toxic materials results in metabolic impairment of the bacteria and a corresponding decrease in light emission. This test provides a rapid, reproducible estimate of acute toxicity, particularly at the bacterial level and is often selected as a rapid screening methodology. EC_{50}s (15 minute, 15^{o}C) were generated using the standard methods set out by the manufacturer in the Microtox System Operating Manual (Beckman, 1982).

DATA ANALYSIS

The raw toxicity data for the daphnid and algal tests (% immobilized, and % growth inhibition respectively) was analyzed using the Spearman-Karber method (Hamilton et al, 1977) and reported as follows:

- daphnia immobilization as the 96 hour EC_{50};
- algal growth inhibition as the 4-day EC_{20}.

Microtox results (% inhibition of light output) were analyzed by least squares analysis (Beckman, 1982) and reported as the EC_{50} (15 min., 15°C).

The results for all replicate tests were combined and mean results (EC_{50}, EC_{20}, EC_{30}) calculated.

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APPENDIX C

EFFLUENT AND WATER QUALITY DATA
ABITIBI-PRICE AND WINNIPEG RIVER (1986)

INDIVIDUAL ANALYTICAL RESULTS*
(mg/L unless noted)

LOCATION	DATE	BOD_5	BOD_5 DISS.	TR	TVR	NFR	VNR	TFR
Station 1	Aug. 25	--	--	84	--	10	--	82
	Aug. 26	--	--	96	--	7	--	81
	Aug. 27	--	--	88	--	19	--	86
	(Ave.)			(89)		(12)		(83)
Mill Effluent	Aug. 25-26	690	580	2102	1000	126	106	--
	Aug. 26-27	615	550	2153	1399	196	178	--
	Aug. 27-28	595	500	2248	1400	198	182	--
	(Ave.)	(633)	(543)	(2168)	(1266)	(173)	(155)	
Station 2	Aug. 25	--	--	108	--	16	--	89
	Aug. 26	--	--	88	--	11	--	85
	Aug. 27	--	--	98	--	16	--	85
	(Ave.)			(98)		(14)		(86)
Station 3	Aug. 25	--	--	94	--	14	--	82
	Aug. 26	--	--	93	--	10	--	91
	Aug. 27	--	--	90	--	15	--	82
	(Ave.)			(92)		(13)		(85)
Station 4	Aug. 26	--	--	96	--	12	--	80
	Aug. 27	--	--	90	--	14	--	80
	(Ave.)			(93)		(13)		(80)
Station 5	Aug. 26	--	--	90	--	16	--	84
	Aug. 27	--	--	83	--	17	--	81
	(Ave.)			(86)		(16)		(82)
Anicinabe School	Aug. 26	--	--	91	--	3	--	89
North Shore Water Plant	Aug. 28	--	--	118	--	11	--	95
South Shore Water Plant	Aug. 26	--	--	106	--	5	--	101
	Aug. 28	--	--	124	--	11	--	103
	(Ave.)			(115)		(8)		(102)

* see page 43 for Key.

LOCATION	DATE	COD	pH (units)	COND. (µmho/cm)	SO_4	TC	IC	OC
Station 1	Aug. 25	—	8.1	95	8	20	10	10
	Aug. 26	—	8.0	95	8	19	10	9
	Aug. 27	—	8.0	92	7	20	10	10
	(Ave.)			(94)	(8)	(20)	(10)	(10)
Mill Effluent	Aug. 25-26	2208	6.8	650	286	750	6	744
	Aug. 26-27	2353	4.7	672	338	785	3	782
	Aug. 27-28	2429	4.3	690	334	790	3	787
	(Ave.)	(2330)		(671)	(319)	(775)	(4)	(771)
Station 2	Aug. 25	—	8.0	95	9	23	10	13
	Aug. 26	—	8.0	94	8	20	10	10
	Aug. 27	—	8.0	93	7	22	10	12
	(Ave.)			(94)	(8)	(22)	(10)	(12)
Station 3	Aug. 25	—	8.0	94	8	19	10	9
	Aug. 26	—	8.0	94	8	19	10	9
	Aug. 27	—	8.0	94	7	21	10	11
	(Ave.)			(94)	(8)	(20)	(10)	(10)
Station 4	Aug. 26	—	8.0	94	8	21	10	11
	Aug. 27	—	8.0	92	7	20	10	10
	(Ave.)			(93)	(8)	(20)	(10)	(10)
Station 5	Aug. 26	—	7.9	95	8	22	10	12
	Aug. 27	—	7.9	96	7	20	10	10
	(Ave.)			(96)	(8)	(21)	(10)	(11)
Anicinabe School	Aug. 26	—	—	—	8	20	10	10
North Shore Water Plant	Aug. 28	—	7.1	160	41	13	9	4
South Shore Water Plant	Aug. 26	—	—	—	13	22	10	12
	Aug. 28	—	7.7	130	11	20	10	10
	(Ave.)				(12)	(21)	(10)	(11)

LOCATION	DATE	COLOUR (TCU)	Na	Hg	Cu	Ni	Zn	Pb	Al	Cd
Station 1	Aug. 25	55	2.82	<.0002	<.02	<.03	0.059	<0.1	0.61	<0.02
	Aug. 26	50	2.71	"	"	"	0.012	"	0.50	"
	Aug. 27	55	2.82	"	"	"	0.015	"	0.49	"
	(Ave.)	(53)	(2.78)				(0.029)		(0.53)	
Mill Effluent	Aug. 25-26	375	162	"	"	"	0.105	"	3.32	"
	Aug. 26-27	445	141	"	"	"	0.096	"	3.24	"
	Aug. 27-28	405	150	"	"	"	0.103	"	4.02	"
	(Ave.)	(408)	(151)				(0.101)		(3.53)	
Station 2	Aug. 25	55	3.44	"	"	"	0.047	"	0.48	"
	Aug. 26	55	2.89	"	"	"	0.047	"	0.56	"
	Aug. 27	50	8.37	"	"	"	0.022	"	0.76	"
	(Ave.)	(53)	(4.90)				(0.039)		(0.60)	
Station 3	Aug. 25	55	2.73	"	"	"	0.020	"	0.60	"
	Aug. 26	50	2.81	"	"	"	0.033	"	0.62	"
	Aug. 27	50	2.84	"	"	"	0.023	"	0.65	"
	(Ave.)	(52)	(2.79)				(0.025)		(0.63)	
Station 4	Aug. 26	55	2.76	"	"	"	0.021	"	0.58	"
	Aug. 27	55	2.69	"	"	"	0.017	"	0.60	"
	(Ave.)	(55)	(2.73)				(0.019)		(0.59)	
Station 5	Aug. 26	45	2.79	"	"	"	0.019	"	0.67	"
	Aug. 27	50	2.93	"	"	"	0.029	"	0.69	"
	(Ave.)	(48)	(2.86)				(0.024)		(0.68)	
Anicinabe School	Aug. 26	35	5.91	"	"	"	0.019	"	0.24	"
North Shore Water Plant	Aug. 28	5	11.0	"	0.46	"	0.828	"	0.35	"
South Shore Water Plant	Aug. 26	45	7.67	"	<.02	"	0.011	"	1.83	"
	Aug. 28	35	6.58	"	"	"	0.019	"	1.59	"
	(Ave.)	(40)	(7.13)				(0.015)		(1.71)	

LOCATION	DATE	PHENOLS	RESIN ACIDS	TANNIN & LIGNIN	TOTAL COLIFORM (MPN/100mL)	FECAL COLIFORM (MPN/100mL)
Station 1	Aug. 25	0.04	—	2.5	12	—
	Aug. 26	0.02	—	2.5	—	—
	Aug. 27	0.10	—	—	—	—
	(Ave.)	(0.05)		(2.5)		
Mill Effluent	Aug. 25-26	1.64	3.0	62.5	—	—
	Aug. 26-27	1.66	—	—	150,000+	4,600
	Aug. 27-28	1.86	—	55	150,000+	110,000
	(Ave.)	(1.45)		(58.8)		
Station 2	Aug. 25	0.03	<0.05	4.0	1,500+	—
	Aug. 26	0.08	—	3.0	39	—
	Aug. 27	0.09	—	—	460	43
	(Ave.)	(0.07)		(3.5)		
Station 3	Aug. 25	0.04	<0.05	3.0	—	—
	Aug. 26	0.02	—	3.0	460	—
	Aug. 27	0.02	—	3.0	93	0
	(Ave.)	(0.03)		(3.0)		
Station 4	Aug. 26	0.01	<0.05	2.5	460	—
	Aug. 27	0.01	—	3.5	—	—
	(Ave.)	(0.01)		(3.0)		
Station 5	Aug. 26	0.03	<0.05	3.0	1,100	—
	Aug. 27	0.04	—	3.5	—	—
	(Ave.)	(0.04)		(3.2)		
Anicinabe School	Aug. 26	0.05	—	—	—	—
North Shore Water Plant	Aug. 28	0.02	—	—	—	—
South Shore Water Plant	Aug. 26	0.04	—	—	—	—
	Aug. 28	0.07	—	—	—	—
	(Ave.)	(0.06)				

KEY

BOD_5	- 5-day Biochemical Oxygen Demand
BOD_5 Diss.	- Dissolved 5-day BOD
TR	- Total Residue
TVR	- Total Volatile Residue
NFR	- Non-Filterable Residue
VNR	- Volatile Non-Filterable Residue
COD	- Chemical Oxygen Demand
COND.	- Conductivity
SO_4	- Sulphate
TC	- Total Carbon
IC	- Inorganic Carbon
OC	- Organic Carbon
COLOUR	- True Colour Units - Platinum Cobalt Std.
Na	- Total Sodium
Hg	- Total Mercury
Cu	- Total Copper
Ni	- Total Nickel
Zn	- Total Zinc
Pb	- Total Lead
Al	- Total Aluminum
Cd	- Total Cadmium
PHENOLS	- Total Phenols
RESIN ACIDS	- Total Resin Acids
TANNIN AND LIGNIN	- As Tannic Acid
COLIFORM BACTERIA	- Most Probable Number